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Louisiana Coast-wide Nutria Control Program: Year Two

Nutria damage along coastal Louisiana was first reported in the late 1980's and was documented during aerial surveys that began in the early 1990's. In January 2002, the Coastal Wetlands Planning Protection and Restoration Act task force approved the Coast-wide Nutria Control Program, a program that provides a $4.00 per nutria tail incentive payment to participants. The program objective was to remove 400,000 nutria from the Louisiana coast and was implemented by the Department of Wildlife and Fisheries. The boundaries of the program area were established and an application process was developed. Applicants were required to have a valid Louisiana trapping license and landowner permission of the property to be trapped / hunted. A map with property boundaries and a legal description of the property, including the township, range and section, was submitted so that harvest distribution information could be obtained. Approved applicants received a registration packet containing all pertinent information by beginning of the trapping season. The open trapping season began in mid November and collections began in late November. Participants brought nutria tails (7 inches or greater) to collection sites spread across coastal Louisiana. Participants also indicated the location of harvest on maps of their property which was used for harvest distribution. The trapping season closed at the end of March and the collections ended the first week of April. A final summary with harvest distribution data was prepared.

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Towards a Risk Assessment of Second Generation Rodenticides: Do We have Enough Information to Proceed?

It is undeniable that the use of second generation anticoagulant rodenticides (SGARs) has resulted in notable conservation successes in various parts of the world where rats threaten the viability of sensitive ecosystems. The recovery of islands following the removal of introduced rodents is so evident that the benefits clearly outweigh the impacts related to the poisoning campaign. However, the fact remains that SGARs are among the most problematical pesticides registered today. The number of rodenticide poisoning incidents has steadily increased over the years to the point that they are now as or more frequent than reported insecticide poisonings despite a much smaller volume of use. In New York State, between 7.2% and 10.6% of all bird of prey mortality reported to the authorities between 1998 and 2001 was the result of anticoagulants, almost exclusively SGARs. For great horned owls, it was as high as 17% (Stone et al. 2003 Bull. Env. Contam. Toxicol.70:34). Mortalities of squirrel, chipmunk, raccoon, opossum, fox, skunk and deer have also been uncovered. In California between 1994 and 2003, SGARs were thought highly likely to have caused the death of 5/8 barn owls examined, 3/6 great-horned owls and 4/14 golden eagles. There also the list of affected mammals is extensive: coyote, fox squirrel, kangaroo rat, raccoon, red fox, mountain lion as well as the endangered San Joaquin kit fox (updated from Hosea 2000 19th Vert. Pest. Conf.: 236).

There is a tendency today to think that a paper risk assessment will provide all the answers we need to effectively understand and manage the risk from products such as these. This thinking has become even more entrenched following the advent of probabilistic methods. These methods provide a veneer of credibility to assessments that often remain very shaky at their core. Probabilistic methods typically provide bounds around the parameters of a model. They do not reveal the uncertainties about the fundamental model structure.

The following questions are essential to the conduct of a credible assessment, whether deterministic or probabilistic. Given the extent of model uncertainties, we do not think it likely that a simplistic risk assessment can provide any meaningful answers at this point.

Do we know enough about the sensitivity of non-target species to SGARs?

Anticoagulant rodenticides are very poor subjects for the usual toxicity determination that underpins all risk assessments. For example, of 31 pesticides with repeat exact LD_{50} determinations within the same species, brodifacoum fared the second worst in terms of inter-test variation with 15-fold difference between calculated LD_{50}s. Lethality from anticoagulant rodenticides is highly dependent on the length of the post-dosing observation period as well as on husbandry issues. Small nicks, cuts or bumps which are part of daily life for a caged bird become life threatening with these compounds. Furthermore, rodenticides are probably the only pesticides that have been tested with a concurrent administration of the antidote at unspecified levels. The pharmacological literature is rife with reports of phylloquinone (vitamin K1) interfering with anticoagulant therapy. Yet, toxicity tests are conducted on animals given a base feed that may be rich in vit. K1 (present at high levels in soy and alafalfa for example) and which is further supplemented with menadione (synthetic vit. K3). There is some indication that at least part of the wide variation in reported brodifacoum toxicity to the mallard may be the result of differential vit. K supplementation. Applying the usual species sensitivity distribution techniques to the existing toxicity database may not be very meaningful if all of the toxicity data points are suspect. Similarly, it is difficult to place too much belief on comparative assessments that are based on toxicity data.

Furthermore, because of the widespread contamination now being reported, the base risk scenario today is not likely to be that of a toxicologically 'naïve' individual being exposed to a residue-carrying mouse or rat. For example, based on the long term UK based Predatory Bird Monitoring Scheme (updated from Burn et al. 2002 Aspects Appl. Biol.: 2003), the proportion of barn owls already carrying residues is approaching 50% and the summed liver residues now average approximately 0.1 ppm. A sample of aymptomatic birds of prey from NY State (Stone et al. 2003 op.cit.) indicate that 77% of great horned owls, 50% of red-tailed hawks, 43% of screech owls and 35% of Cooper's hawks have been exposed. Recent data from central Canada (Ontario and Manitoba samples) obtained with a sensitive triple quadrupole LCMS-MS instrument indicate that it is becoming difficult to find uncontaminated great horned owls in populated areas and that the majority of birds now carry multiple rodenticide residues, primarily SGARs. Whereas the toxicological significance of these residues is not known, we can surmise a general increase of susceptibility to anticoagulation as a result of this extensive pre-exposure in wildlife populations.

Do we know how non-target species such as birds of prey are exposed?

The dominant routes of exposure are thought to be clear in the case of birds of prey that are acknowledged to take commensal rodents on a frequent basis – for example barn owls worldwide, red kites in the UK. However, patterns of exposure both in the UK and in North America suggest much broader contamination of the terrestrial environment. For example, the high frequency of exposure in Cooper's hawks from New York State (35%) was unexpected based on the absence of commensal rodents from the known food habits of the species (Rosenfield and Bielefeldt 1993 Birds of N. America). The relatively small proportion of poisoning cases despite the high frequency of occurrence suggests that this species may not be getting exposed through ingestion of poisoned rodents but, rather, through an invertebrate-bird food web. Such a transfer of residues through invertebrates to insectivores has been shown to occur including during whole island rat control programs (e.g. Howald 1997 U-B.C., M.S. Thesis). The extent of insectivore food chain contamination in agricultural and sub-urban landscapes has yet to be confirmed.

Examples of exposure to multiple rodenticides abound from the U.S., UK and Canada. This may be a result of very frequent exposure to poisoned rodents or again denote a very widespread contamination of the environment at large. A complicating factor has been the discovery of cross contamination of rodenticide products at trace levels. Our latest data from Ontario suggest multiple exposure rather than widespread cross-contamination of bait material. In any case, based on the great horned owl data mentioned earlier, it is prudent to assume that all members of a population of raptorial species will be exposed to contaminated prey regardless of what the literature says about their preferred food habits.

Information from the UK appears to suggest that restricting anticoagulants to indoor use results in a lower level of environmental contamination as witnessed by the smaller preponderance of brodifacoum and flocoumafen (indoor use only – only 1-6% of barn owls carry residues) relative to that of difenacoum and bromadiolone (indoor and outdoor use – 20-30% of barn owls carry residues). However, the difference is readily explained by sales volume alone. If one looks at brodifacoum residues, for instance, the frequency of detection in barn owls is approximately 4 times the frequency of difenacoum or bromadiolone detection based on the number of farms using the product. The more restrictive labeling, therefore, does not result in a lower frequency of detection in the barn owl at least. Unfortunately, good use data is lacking for the North American market.

Do we understand the consequences of sublethal exposure?

The vast majority of aymptomatic birds in which we find low levels of rodenticides have obviously survived acute intoxication. This does not mean that there are no other possible consequences of this contamination. This is an aspect that has been mentioned by several researchers. Concerns remain because of possible hepatotoxicity as well as disruptions of osteocalcin-dependant processes whether loss of calcium leading to osteoporosis or calcium remobilization and deposition in the circulatory system. The increased sensitivity of these birds following a re-exposure has already been noted earlier.

A particularly worrisome research finding has been the report of brodifacoum toxicosis in neo-natal dogs following a past sub-lethal exposure in the female (Munday and Thompson 2003 Vet. Pathol. 40:216). The risk of trans-placental transfer is of obvious concern given the high proportion of mammals found carrying residues including endangered species such as the kit fox.

In short, we find ourselves in the same situation now than in the early days of the discovery of widespread contamination of non-target species by organochlorine insecticides. We can see the extent of the contamination but cannot yet understand all of its ramifications. It is doubtful that answers to these questions will come from a risk assessment process developed to deal with typical pesticides of short environmental persistence. Until we fully understand the consequences of environmental contamination from SGARs, it behooves us to weigh very carefully the benefits of their use.

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Rodent Declines and Invasions in the Florida Keys

The critically endangered Key Largo woodrat has undergone a serious decline in recent years. A population viability analysis was conducted in 2003, predicting extinction of the species within 10 years. Trapping conducted during 2003-2004 continues to indicate a declining population. A captive breeding program was initiated at Lowry Park Zoo and the first young were produced on May 10, 2003. To date, 13 wild-caught woodrats have been brought into captivity (9 males and 4 females) and 14 young have been produced.

Assumed threats for the Key Largo woodrat population in the wild include secondary impacts as a result of development including black rats, cats (feral and domestic), raccoons, and fire ants. The effects of these threats on the Key Largo woodrat population are difficult to evaluate because few data are available on the abundance of these species. The magnitude of threat from each of these species on the woodrat is difficult or impossible to determine without further study. All of these species are widely-accepted threats to small mammal populations, though we do not have direct evidence of their impacts on the Key Largo woodrat. Some of these impacts have been temporarily addressed. Any incidental black rats captured during woodrat trapping efforts were removed and necropsied to determine if any diseases are present in the black rat population that may potentially affect the Key Largo woodrat population. During 2003-2004, USDA/APHIS Wildlife Services was contracted to remove feral cats from north Key Largo. Fire ants are being treated on the right-of-way on County Road 905. No noticeable rebound has been observed to date in the Key Largo woodrat population as a result of these actions.

Anecdotal information on a new invasive species has recently been reported in Key Largo. The Gambian pouch rat has now been documented to occur on Grassy Key and unconfirmed sightings of Gambian pouch rats have been reported in Key Largo. Although no control or eradication measures are currently underway, some trapping is being conducted by a graduate student from Texas A & M University. Captured individuals are being tested for possible zoonotic diseases.

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An Overview of Rodent Contraceptive Development at the USDA/APHIS Wildlife Services, National Wildlife Research Center

Rodent control has traditionally be accomplished by lethal methods. Contraceptive methods are currently experimental, but the potential for effective control using contraceptive agents is promising. Because different contraceptive methods may be advantageous in different situations, development of a variety effective fertility control measures may be valuable. Contraceptives in general have some advantages over poisoning that will be useful in some rodent control situations. Bait shyness should not occur with contraceptives because the result occurs later than ingestion. In most cases, contraceptives are safer to humans and non-targets than lethal control chemicals. Non-lethal control is generally more accepted than lethal control. And some contraceptives may actually provide better population reduction than lethal control.

A collaborative effort with government agencies in California demonstrated that contraceptive methods can be used in rodents. The overabundant California ground squirrels were in a park where lethal control was not an option. An injectable GnRH vaccine was used in the ground squirrels. The effort was successful as measured by several parameters, but the trapping required to be able to inject the vaccine was time consuming.

Because injection is not practical in most situations, development of oral contraception methods would be a great advantage. Both chemical compounds and oral contraceptive vaccines are under development at NWRC. The potential for chemical inhibition of fertility has been demonstrated in preliminary studies. Further investigation is ongoing. Developing effective oral vaccines is difficult, but NWRC scientists are working on several possible formulations that may make effective oral immunization possible.

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Assessing Potential of Applying Baits on Native Marshes to Reduce Nutria Impacts

Nutria (*Myocastor coypus*) were first introduced to the United States for their fur, and some populations remain economically important to the fur industry. Accidental and intentional releases have permitted them to establish in wetlands across the United States. Burrowing and foraging by nutria can be devastating to native vegetation. Nutrias are recognized as factor in a decline of native marsh along the Louisiana coastal and on the Chesapeake Bay. Placing zinc phosphide treated baits on rafts in canals or ponds has effectively reduced nutria numbers on croplands. However, a similar effort on native marshes may not work as well. Bait acceptance may be low because nutria may elect to ingest alternative native foods and non-target impacts may be different. We conducted a series of experiments in cooperation with the Louisiana Department of Fish and Wildlife to assess potential of applying baits on native marshes. An initial study revealed low bait acceptance during late spring, possibly because an abundance of marsh plants. This study was repeated during the following winter when native plants were less abundant. Nutria activity on rafts remained low, foraging activity markers indicated that only 4% of the population had consumed bait treated with metallic flakes and tetracycline. Related studies assessed the use of olfactory, visual and audio attractants to encourage nutria use of rafts. Although a strong attractant was not obvious among tested stimuli, nutria appeared responsive to olfactory cues. Visual and audio cues were not well attended.

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Invasive Species Research at the USDA National Wildlife Research Center, Hilo Field Station

Introduced rodents have historically caused a myriad of health, economic, and environmental problems in Hawaii and the Pacific Basin. The roof rat (*Rattus rattus*), Norway rat (*R. norvegicus*), Polynesian rat (*R. exulans*), and house mouse (*Mus musculus*) are found in many diverse habitats throughout the major Hawaiian islands. Since 1967, the NWRC Hawaii Field Station, located on the island of Hawaii, has been actively conducting research to reduce the impacts of these invasive vertebrates in agricultural crops and on rare and endangered native floral and faunal resources throughout the Pacific Basin. The agricultural emphasis has historically focused on sugar cane and macadamia nuts, but more recently has shifted to tropical fruits, ornamental foliage and flowers, seed corn, vegetables, and other crops. The Hawaiian Islands are known to have the greatest number of endangered plant and animal species in the world. Rare native plants, snails, invertebrates, and birds are severely threatened by disease, loss of habitat and predation. Rats rank high as predators that are responsible for suppressing seed regeneration of endemic plants, reducing populations of native snails, and significantly limiting the breeding success of many native avian species. Field Station staff have been actively working to develop rodenticides to use in conservation areas to either reduce rat effects or to eliminate them when possible. **[POSTER]**

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Accidental Discharge of Brodifacoum Baits in a Tidal Marine Environment: A New Zealand Case Study

Brodifacoum is a second-generation anticoagulant used worldwide in bait formulations for commensal rodent control, and in some countries for field control of vertebrate pests. As the result of a New Zealand road transport accident in May 2001, a tidal marine environment was exposed to up to 18 tonnes of rodent bait (c. 360 g of brodifacoum) as a point source, which was an unprecedented incident. Immediate monitoring of marine biota, water and sediment was undertaken. This was particularly important because the area was used for human food collection. No local mortalities of marine birds or mammals were attributed to the spill. Contamination of the marine environment was localized in about a 100-m^2 area. The decline of brodifacoum residues in algal-grazing and filter-feeding marine invertebrates over a three-year period is described. A ban by New Zealand authorities on the collection of shellfish from the area was lifted in May 2004. The decline of brodifacoum residues in various sample media was probably due to a combination of physical dispersal (rather than chemical degradation) of brodifacoum in the highly dynamic tidal marine environment, and a previously undescribed and relatively long retention (half-life) of brodifacoum in marine molluscs.

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Managing Roof Rats (*Rattus rattus*) to Reduce Their Impacts on Open-cup Nesting Songbirds in Riparian Forests of the Central Valley, California

In 2001, we identified roof rats (*Rattus rattus*) as potential predators of songbird nests in old growth riparian forests of California's Central Valley. With nest predation rates for some open-cup nesting species as high as 80% in some years, and extremely high trap success of roof rats in songbird nesting areas, it was clear that a cost-effective management strategy to reduce rat impacts on songbirds was necessary. Following a review of the literature and consultation with land managers and experts in rodent management and bird conservation, we developed a baiting strategy aimed at reducing rat populations immediately prior to the songbird nesting period. We conducted studies to provide information on rat home range and habitat use, the most effective bait, optimal bait station placement and distribution, and the potential non-target hazards of the program. We implemented the baiting strategy in one riparian forest tract in October – December 2003, with maintenance baiting during the spring songbird nesting period. Preliminary results indicate that the strategy was effective in reducing rat populations and their predation on nesting songbirds. Although material costs were relatively low, the labor involved in placing and monitoring bait stations, and the inaccessibility of densely vegetated sections of riparian forests may be impediments to implementing this strategy on a larger scale.

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Chlorophacinone Baiting for Belding's Ground Squirrel

In May 1996, efficacy investigations were conducted by the USDA National Wildlife Research Center (NWRC) near Dorris, CA using 0.01% chlorophacinone (CAS No. 3691-35-8) on steam-rolled oat (SRO) groat baits (EPA SLN CA-890024) as a rodenticide. Chlorophacinone was applied by spot-baiting/hand baiting methods using 0.01% SRO baits (i.e. bait scattered around burrow entrances). Spot-baiting was used to control free-ranging Belding's ground squirrels (*Spermophilus beldingi*) in alfalfa (Medicago sativa). Study design included six square treatment units (TUs), 4 treated with chlorophacinone and 2 were treated with a placebo (SRO groat baits without the chlorophacinone). Each TU was 0.4 ha (1.0 acre) and to reduce post-treatment ground squirrel immigration on to the TU a square 5.5 ha (13.8 ac) buffer zone was established around each TU and was similarly treated. A minimum of 50 m (164 ft.) separated all buffer zones. The baits were formulated by a commercial supplier; quality control assays indicated the mean percent of chlorophacinone (w/w) was 0.0109% (SD± 0.00008%) for the nominal 0.01% bait. Bait (11.5 g) was applied according to label specifications by trained applicators on May 13, 1996. Baits were reapplied on May 20 and May 22 for spot-baiting, because of 9 days of unforecast wet weather that greatly decreased ground squirrel activity and made the spot baits swell by absorbing water. As a result, the baits were not preferred forage for the ground squirrels. On May 20, following increased ground squirrel activity with warmer and drier weather, fresh bait was scattered around each active burrow entrance and a second spot-baiting was done on May 22. Following baiting, TUs were searched daily and all intact Belding's ground squirrel carcasses were frozen and kept for tissue analysis. Efficacy of spot-baiting (uncorrected and corrected % reductions), as measured directly by visual counts (73.5% and 64%) and indirectly by open-hole index (80% and 68%), was near the EPA's 70% recommended minimum efficacy standard for rodenticides. Thirty-eight carcasses were analyzed from the spot-baiting TUs by the Analytical Chemistry Project (ACP) at NWRC for chlorophacinone. Of these, 29 (80%) had detectable levels of chlorophacinone in the liver averaging 0.1279 ppm (SD $\pm$ 0.1314 ppm) and in the whole body averaging 0.1131 ppm (SD $\pm$ 0.0928 ppm). Non-target mortality was not observed in this study. In conclusion, spot-baiting was an effective method to control Belding's ground squirrels, and it could be improved with use: (1) earlier in spring when less alternative forage was available, (2) before the emergence of the young-of-the-year, (3) during drier weather conditions associated with increased ground squirrel activity, and (4) of a third baiting following about 2 days after the second baiting. **[POSTER]**

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Elevated Bait Station Trials (and Tribulations) in Crab Country

In an effort to develop the most efficient rat bait station that limits hermit crab depredations, many methods were researched, then tested on Wake Atoll, Pacific Ocean. Local designs from Wake were already being tried to control rats in the post cat eradication predator release. PVC tube and metal stations were screwed into trees in order to limit bait take by land crabs. These models appeared ineffective. Stand-alone Phil-Proof™ and Rat-Go™ models were also tested. The stand-alone Rat-Go™ model was tried extensively in Jul-Aug. 2004. It was initially found to allow crabs to climb up the front and rear supports. As a means to deter climbing, the front edges were wrapped in mylar to prevent crabs from gaining an edge to hold. Rats were initially not recorded entering because the crabs got there first, but the mylar bib showed promise and also recorded rat tracks on its smooth surface when wet with dew. Finally, the supports were indented about one and a half inches. This modification allowed crabs to climb up, but prevented them from gaining entry due to the distance to the edge. Crabs shimmied up and hit the underside of the station and slid back down. Several nights of trials in heavy crab use areas showed the design to be effective in limiting crab depredations while allowing rat access. Modifications were made and Rat-Go™ Elevated Bait Stations were manufactured and are ready for more field trials. **[POSTER]**

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Registration Costs of New Products and New Uses: The Price of Innovations and Solutions

Registration work makes up a significant part of the cost to develop new pesticide products and new uses for existing pesticides, including rodenticides. For a product based on a new active ingredient the research and development phase (R&D) can take 3-7 or more years to generate up to 70 data endpoints to qualify a new material for U.S. Environmental Protection Agency (EPA) registration. All research must be done according to the Good Laboratory Practices (GLP). Conducting all the trials possibly needed to register a new conventional chemical pesticide can cost 50 million dollars in research investment. Clearly, rodenticides can not justify such expense, but the R&D bill for a truly "new" product could easily exceed 2 million dollars. New uses for existing products carry less development expense, but costs remain an important consideration. Figures for R&D do not include registration fees. EPA's review of registration dossiers is now subject to the Pesticide Registration Improvement Act (PRIA) of 2003, with 90 different categories for pesticide registration service fees. The PRIA is intended to create a more predictable evaluation process for affected pesticide decisions, and couples the collection of fees with specific decision review periods. The legislation also promotes shorter review periods for reduced-risk applications. Fee waivers and reduced fees are available in certain situations, such as IR-4/minor uses, federal and state agency exemptions, and small business registrants. The fee for EPA's Registration Division to review a New Rodenticide Active Ingredient for "Non-food use, outdoor" applications is $330,000 for registrants not eligible for waivers. Depending on when data is submitted, the decision review period would be 21 to 32 months for this category. The Agency's fee to review a New Use for an existing rodenticide for "non-food use, outdoor" applications is $20,000 for waiver-ineligible registrants, and the decision review period would be 15 to 28 months. While invasive rodent problems can be partially solved by the judicious use of rodenticides, new technological developments in this arena will carry a price tag for such innovations and solutions.

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Hantaviruses in the Western Hemisphere: A Review

Several hantaviruses can be found throughout the Western Hemisphere. Some of these New World hantaviruses are etiologic agents of hantavirus pulmonary syndrome, an often fatal zoonotic disease. Several species of rodents belonging to the family Muridae are the primary hosts of New World hantaviruses. Through years of research, multiple workers have indicated that each hantavirus typically has a single primary rodent host (e.g., the deer mouse, *Peromyscus maniculatus,* is the host of Sin Nombre virus); however, multiple workers have documented antibodies to a hantavirus in rodent species not known to be a primary host of a hantavirus. In this talk, virus/host relationships, transmission cycles, and risks to humans are reviewed for hantaviruses found in the New World.

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Sero-survey for Antibodies to Flaviviruses in Wild Mammals in Central and Eastern United States

Sero-surveys were conducted to detect antibodies to flavivirues and West Nile virus (WNV) in wild mammals. Two different monoclonal antibodies (6B6C-1 and 3.1112G) were used. More than 500 serum samples from over twenty mammal species captured in five states (CO, LA, NY, OH, and PA) were screened. Sera samples containing antibodies to flaviviruses were screened for WNV-specific antibodies and confirmed with plaque reduction neutralization tests. Antibodies to flaviviruses were detected in multiple species. This number was significantly reduced for WNV as was the overall prevalence of antibodies, indicating that multiple flaviviruses may have been present at some study sites. High prevalence rates for WNV antibodies were noted among raccoons, Virginia opossums, fox squirrels ,and eastern gray squirrels. **[POSTER]**

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Rodent Control Techniques: Can We Learn from Agricultural Uses?

Rodents are controlled in many different agricultural settings. While the primary reason for these programs is to reduce economic damage, the overall goals are similar to many rodent control efforts for conservation of wildlife or natural resources. Since most agricultural rodent control programs are based, or at least theoretically conceived, on a cost/benefit model, the control is done when it is economic for the producer. In conservation efforts, the same model is used but the control threshold is likely at a different level. While eradication is often the goal in conservation efforts, it is seldom the definition of success in agricultural situations. However, much effort and research on agricultural rodent control is focused on improving efficacy; making the pest control goals for agricultural and conservation much the same. In this presentation, I will review some baits (include their composition), baiting strategies and application equipment that are all used in agriculture to improve the efficacy of the control program while reducing primary and risks to non-target species. An understanding of